the connecting tube *E* and the pump a bulb containing phosphoric anhydride must be placed. The whole apparatus, suitably supported, is now completely exhausted by running the pump continuously for hours, occasionally heating the tube *A B* with the flame of a Bunsen burner. *C* should also be heated until mercury vapor is somewhat freely given off to drive out moisture and air. By this method all moisture in the mercury, together with the film of air which obstinately adheres to the inside of the tube, can be as nearly as possible removed. When this has been accomplished, the retort *C* is carefully heated to distill the mercury over into *A B*, where the mercury condenses in small globules, which do not form pistons in the tube, and which run down the lower side of *A B*, thereby displacing any residual air. The distillation is continued until *A B* is filled; the pump is kept in action all the time. By the continuous action of the pump the vacuum is kept as complete as possible during the entire operation. The tube *E* is then cut from the pump to let air into the retort. The barometer tube is cut off at *F* and immersed in mercury with the usual precautions. Tubes that we have filled by this method show not the slightest trace of air when inclined.

The essential feature of the method consists in distilling the mercury into an inclined tube of such an internal diameter that the mercury collects in globules, which run down the lower side of the tube, instead of forming pistons, which would imprison and carry down the residual air, thus rendering the vacuum imperfect. Tubes of internal diameter greater than one-eighth inch are large enough to be filled in this manner. If the bore is less than one-eighth of an inch, the mercury will form pistons and carry down the residual air.

The method is the result of experiments carried out by my father, Mr. D. A. Partridge, and myself.

At first sight the above method seems almost completely identical with that described by Waldo in the American Journal of Science, 1884, Vol. XXVII, p. 18. I do not believe, however, that a good instrument could be made by Waldo's method, since the mercury, when distilled into his vertical tube, would form pistons and carry down air. He says that watch must be kept to see that no air is carried down. I have tried his method with a mercury pump, giving far better vacua than pumps of the form then in use could give, and have always found minute air bubbles entangled in the mercury. I therefore think that my method, if not wholly new, is really an important one and a real advance. Another important difference between my method and that of Waldo is that I keep the pump working during the entire distillation, and he stops his before commencing.

[Further details as to filling large tubes that are to be used for either barometers or manometers will be found in Professor Marvin's articles on vapor pressure and on a normal barometer in the Annual Report of the Chief Signal Officer for 1891, Appendix 10. The admirable barometer of Sundell (*Acta Societatis Scientiarum Fenicæ*, Vols. XV and XVI, Helsingfors, 1885 and 1888) is fully described in Waldo's Modern Meteorology, London and New York, 1893, to which we would refer our readers for many other details as to the advanced state of physical apparatus and mechanical theories that constitute modern meteorology.—ED.]

THE COLD SPELL OF NOVEMBER 16-30, 1896, IN MONTANA AND ADJOINING STATES.

By PROF. H. A. HAZEN (dated December 21, 1896)).

A remarkable depression in temperature occurred in the Northwestern States during the last two weeks of November. At Havre, Mont., the culmination was on the 18th, p. m., with a temperature of 54° below normal, though on the 29th, p. m., it was —51°. Not the least singular fact in this connection is the abnormal warmth in the Middle Atlantic States, where for a considerable area the temperature during the same time was 10° above normal. Charts VIII and IX of this REVIEW show the average departure from the normal for each day of these two weeks. A very good idea of the extent and severity of this cold spell may be obtained by comparing it with the coldest November experienced in the past twenty-seven years, that of 1880, as follows:

Stations.	Departure from normal.	
	1880.	1896.
	°	°
Havre, Mont	— 9	—27
Helena, Mont	—11	—15
Miles City, Mont	— 8	—19
Williston, N. Dak	— 7	—22
Bismarck, N. Dak	— 9	—20
Rapid City, S. Dak	—12	—16
Pierre, S. Dak	— 8	—20

The limited extent of the present cold spell may be shown by a comparison with a few stations on its border: Salt Lake City, 1880, —9°, 1896, —2°; Kansas City (Leavenworth), —8° and —3°; Columbia, Mo., 1896, + 2°; Alpena, Mich., —7° and + 2°; Amarillo, Tex. (Fort Elliott), —12 and —3°. Another point to be noted is that while the extreme cold of 1880 extended over the whole country, for example, Vicksburg, —8°, Atlanta, —4°, Charlotte, —5°, Washington, —4°, and Eastport —2°, that of 1896 was limited to a few States in the Northwest, whereas in the Middle Atlantic States, November, 1896, was the warmest since 1870, and at Philadelphia it was the warmest in seventy-five years (records before 1870 a little doubtful, stations in the city differing 2° or 3° in the same month).

A study of the weather conditions accompanying such marked anomalies in temperature would be of interest in helping to explain them. As already noted there was a permanent area of high pressure over the Northwest during this period, departure from normal + .50 inch at Havre and + .43 inch at Bismarck. This could not have been due to a too great reduction to sea level because of the low temperature, for Bismarck is only 1,690 feet above sea level, and the change for temperature is small at that height.

This distribution of pressure produced northwesterly and westerly winds in the Missouri and upper Mississippi valleys, but in the middle and lower Mississippi valleys to the Atlantic the winds were southeasterly, southerly, and southwesterly. On the south Atlantic Coast, northeasterly winds from the ocean tended to keep the temperature up. Comparing the pressure distribution with that of 1880, we find in the latter year high pressures over the whole country, and in consequence the winds mostly north and northwest, except in a portion of the lower Lake Region, where they tend toward southwest. It is evident that the winds will account for a part of the anomalous conditions in these two years but not for all.

Turning now to the daily weather maps we find in 1880 a succession of highs appearing to the north of Montana and traveling clear across the country, producing distinctive cool or cold waves due to the advance of the high. In 1896, on the other hand, there were almost no highs advancing across the country, and there were hardly any cool waves. This was particularly the case in the Northwestern States. This seems a key to the whole situation. Almost stagnant high areas in the Atlantic States and in the Northwest produced the abnormally high pressure in 1896, while the uniform motion of highs in November, 1880, produced the uniform high pressure over the country.

It remains to inquire why the stagnant high areas in the Northwest gave such low temperatures, while apparently, the

same condition tended to abnormal heat in the Southeast. The solution of this problem is to be sought in the upper atmosphere. The clear, dry air of the Northwest permitted intense heat radiation to the sky, and day after day this was maintained without the interference of moist lows from the Pacific. In other words, we have here an excellent example of the intense radiation-cold experienced in Siberia in the stagnant high pressure of that region, sometimes reaching 31.70 inches. On the other hand the moister air of the Southeast permitted the heat of the low latitude sun to penetrate to the earth, and after the heat reached the earth the moisture prevented its radiation into space. The most important point in this whole discussion is the sharp distinction to be drawn between a radiation-cold, pure and simple, and the cold of our cold waves advancing across the country at 40 and more miles per hour.

NOTES BY THE EDITOR.

SIMULTANEOUS BALLOON ASCENSIONS.

The recent International Meteorological Conference at Paris indorsed the importance of cooperation between the governments and individuals who are now so enthusiastically prosecuting the exploration of the atmosphere and the study of meteorology with the help of the balloon. Perhaps the most important point upon which these can unite is the attempt to secure approximate simultaneity in their ascensions. As the exploring balloon may be sent up without any passengers or aeronauts, but may carry accurate self-recording instruments into regions and temperatures that are inaccessible to man, there is nothing impracticable in the proposal that ascensions be made on any given day at many places over a wide extent of country, so as to give us a general view or possibly a detailed map of the condition of the upper air at that time. Such a series of simultaneous ascensions will undoubtedly frequently be made from European stations, under the general guidance of the special committee on aeronautics recently appointed by the Paris Conference, and in a spirit of scientific cooperation, rather than of national or personal rivalry. Such work was begun by the *Deutscher Verein zur Förderung der Luftschifffahrt*, in Berlin, in 1894, and the first results are collected in a paper by Assmann in the *Zeitschrift für Luftschifffahrt*, XXIV. The first simultaneous ascensions were made from Berlin and St. Petersburg, August 4, and the second, August 9, 1894. A third set, of three ascensions, was made October 1, from St. Petersburg, Warsaw, and Ossowicz. Meantime, in September, 1894, three balloons, the Phœnix, Majestic, and the unmanned exploring balloon Cirrus, with self-registering apparatus, made a simultaneous ascension on the 6th, and as soon as practicable after that the Majestic made a long voyage through the night of the 5th and the daytime of the 6th of October. On December 4 Berson ascended from Stassfurt and descended at Kiel.

The ascensions made November 14, 1896, may be considered as the beginning of a long series of similar international investigations of the atmosphere by means of simultaneous balloon ascensions covering all of Europe. On that date the lowest temperatures observed and the greatest heights attained by balloons at different localities were as follows:

Place.	Height.	Temperature.	Remarks.
	Meters.	°*C.*	
St. Petersburg..	5,000	—24	—27.5° at 4,300 meters.
Warsaw	2,000	—20	
Berlin.....	6,000	—25.6	
Do.....	5,650	—24.4	Warm air below 3,000 meters.
Strasburg	7,700	—30	—30.0° at 6,000 meters.
Paris.....	15,000	—60	
Munich	3,500	— 6.5	

The above observations represent the conditions prevailing in the midst of a large area of high pressure that was moving slowly eastward over Europe. At Strasburg and Berlin a layer of warmer air was noted before ascending into the colder air above. On the 14th, 7 a. m., the central isobar of 765 millimeters extended from Finland southward to Greece, and on the 14th, 9 p. m., the isobar of 770 millimeters extended from St. Petersburg south to Bulgaria. The sky was generally cloudless during these balloon ascensions, but cloudy weather soon followed with continued cold at the earth's surface and high pressure from France eastward to the Ural. To the north of this belt temperatures were not abnormally low. Evidently this ridge of 775 to 785 millimeters, extending southeast and northwest between two low areas, represented the slow descent of cold, dry air which flowed away in all directions near the earth's surface; the whole system of sea-level pressures and temperatures could have resulted from a general eastward movement and very slow descent of the layer of cold upper air that was reached by the balloons on the 14th; eventually, it disappeared in the southeast of Europe moving toward Persia. The temperature of a mass of slowly descending dry air follows the laws explained by the Editor in American Meteorological Journal, 1892, VIII, pp. 537–552.

The idea of these simultaneous ascensions seems to have been first urged in 1894 by Berson and Assmann, the assistants of von Bezold in Berlin, and was by them urged upon the attention of the Paris Conference, which voted to encourage such ascensions.

[It may be worth recording that the importance of utilizing simultaneous balloon ascensions and the defects to which our knowledge is subject as long as we neglect the use of the balloon were fully appreciated by the present Editor, who has not failed to urge the systematic scientific use of special balloon voyages and as early as 1871 entered upon his daily weather maps the records of the various ascensions made by professional aeronauts for business purposes; thus, on July 4, 1871, 1872, 1873, respectively, he was able to study the paths of from three to five balloon voyages.—ED.]

In a recent letter from Berson to Hermite, as published in the Aerophile (Oct. 1896, p. 223), Berson corrects several errors which if uncorrected might discourage others from attempting similar work. He says:

1. All the high ascensions of the balloon "Cirrus" from Berlin, so far as they have been published, have been made with ordinary illuminating gas and not with hydrogen; with this gas a height of 18,300 meters has been attained (this altitude is computed after making careful allowance for the temperature of the air and the barometric errors) the great altitudes attained by the "Cirrus" are to be attributed only to the dimensions of the balloon, whose volume is 250 cubic meters.

2. The voyages of the "Cirrus" had nothing whatever to do with the Industrial Exposition of the City of Berlin; they were not for show or sensation but were a part of the systematic work undertaken by the aeronauts and meteorologists of Berlin with the assistance of the German Government and, especially, of the Emperor in person.

3. The German balloon "Cirrus" has not yet been furnished with apparatus suitable for bringing down specimens of the upper air for chemical analysis but has been confined hitherto by Mr. Assmann, to the determination of temperature, pressure, and wind for which purposes the most exact methods have been used.

[As the examination of the moisture contained in a specimen of air brought down from the highest regions would be an admirable check upon any record made by a self-register-